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NRL/MR/6754-93-7322

A Compact, Four-Way Image Splitter

D. P. MURPHY

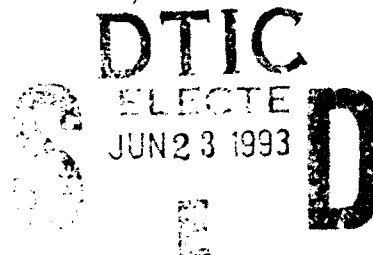
*Charged Particle Beam Physics Branch
Plasma Physics Division*

T. A. PEYSER

*Lawrence Livermore National Laboratory
Livermore, CA*

R. E. PECHACEK

*SFA Inc.
Landover, MD*



May 26, 1993

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REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
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1. AGENCY USE ONLY (Leave Blank)	2. REPORT DATE May 26, 1993	3. REPORT TYPE AND DATES COVERED Interim		
4. TITLE AND SUBTITLE A Compact, Four-Way Image Splitter			5. FUNDING NUMBERS PE - 61153N	
6. AUTHOR(S) D. P. Murphy, T. A. Peyser,* and R. E. Pechacek**				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Research Laboratory Washington, DC 20375-5320			8. PERFORMING ORGANIZATION REPORT NUMBER NRL/MR/6754-93-7322	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Office of Naval Research 800 North Quincy Street Arlington, VA 22217-5660			10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES *Lawrence Livermore National Laboratory, Livermore, CA 94550 **SFA Inc., Landover, MD 20785				
12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited.			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) A compact, four-way, optical image splitter is described which maintains equal intensity and equal optical path length in each arm of the apparatus. The four output beams are collinear with the input light beam.				
14. SUBJECT TERMS			15. NUMBER OF PAGES 12	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT UL	

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A COMPACT, FOUR-WAY IMAGE SPLITTER

I. INTRODUCTION

Digital television cameras can be used for fast image acquisition to characterize visible aspects of a short pulse experiment. When an event is not reproducible it is necessary to use multiple cameras that share a common field of view and can be sequentially triggered within a single pulse duration to characterize the event. The Kentech Instruments Ltd. gated optical imager (GOI) television camera system consists of four separate, independently triggerable, intensified video camera systems with subnanosecond gate capability. The four cameras are grouped in a square array with 2.125" minimum spacing between the CCD active elements. An image splitting system previously devised for use with this camera system used a large space frame on which were mounted optical components that provided equal intensity splitting but not equal optical path length.[1] The design described in this report used off-the-shelf, 1" aperture, prisms and beamsplitters[2] and 1/2" thick aluminum mounting plates. It also provides for equal path length and equal signal attenuation in each arm while being compact and rugged.

II. PHYSICAL DESCRIPTION

The splitter assembly consists of seven right angle prisms, mounted as totally reflecting mirrors, and three cube beamsplitters that provide for equal intensity division. Figures 1 and 2 show, respectively, a scale drawing and a schematic view of the splitter assembly. An aluminum coating was applied to the hypotenuse of each right angle prism so one did not have to rely on total internal reflection at the glass-air interface. All input and output surfaces have antireflection coatings. Mirror M1 turns the light from the original optical axis into the plane of the assembly and into the first beamsplitter BS1. M1 may be mounted separately from BS1 but it is preferable to optically cement it to BS1 to prevent misalignment. The twin beams from BS1 are reflected by mirrors M2 and M3 into the beamsplitters BS2 and BS3 to generate four equal intensity beams. Again, these mirrors can be cemented to their respective beamsplitters or mounted separately. Finally, mirrors M4 through M7, which are arranged in a square grid with a 2.125" center-to-center spacing, are used to direct the four beams out of the plane of the assembly and parallel to the original input beam direction. The beams emerge through four holes in the mounting plate to which the four GOI cameras are attached. The output optical axis is collinear with the input optical axis but it has been offset a distance of 4.373" by the splitter assembly. The right angle prisms used as mirrors M4 through M7 were clamped by their sides in this assembly, but in some applications it may be easier to clamp them from above. Then plain glass prisms can be cemented to the back of each totally reflecting prism to form cube shaped mirrors. Figure 3 is a photograph of the assembled lens system, 4-way splitter, and the four gated cameras. The splitter assembly is only 2" thick and about 10" on a side. The

overall size is determined by the spacing between the camera elements and could be scaled up or down as needed for other applications.

III. OPTICAL CHARACTERISTICS

Each arm of the assembly has an equal optical path length and, with matched beamsplitters, equal intensity division. The transmission and reflection coefficients for the beamsplitters were $T \approx R = 45\% \pm 2\%$. This permitted consistent gain settings on each camera. The advantage of equal optical path lengths is that a converging image from an external lens system will have the same focal plane at each of the four camera heads. Therefore, only a single adjustable optical element is needed in the entire optical train to focus the image. However, the sequence of reflection or transmission (R or T) of a beam at the central interface of each of the two beamsplitters in its optical path causes the orientation of each output beam to be different.[Fig 4] One image is upright and correct upon exiting the apparatus (T-T), another is flipped about both the horizontal and vertical axes in the image plane (R-R), the third image is flipped about the vertical axis in the image plane (T-R), and the last is flipped about the horizontal axis in the image plane (R-T). The digital image analysis software provided with the GOI hardware includes standard algorithms to reorient each captured image so that all share a common final orientation.

IV. ACKNOWLEDGMENT

This work has been supported by the Office of Naval Research.

- [1] P.E. Young, J.D. Hares, J.D. Kilkenny, D.W. Phillion, and E.M. Campbell, Rev. Sci. Instrum. 59 (8), August 1988.
- [2] Prisms and beamsplitters manufactured by Melles-Griot Inc. Prism part number is 01-PRT-021/078. Beamsplitter part number is 03-BSC-009.
- * T. A. Peyser, Lawrence Livermore National Laboratory, Livermore, CA 94550
- ** R. E. Pechacek, Sachs-Freeman Associates Inc., Landover, Md 20785

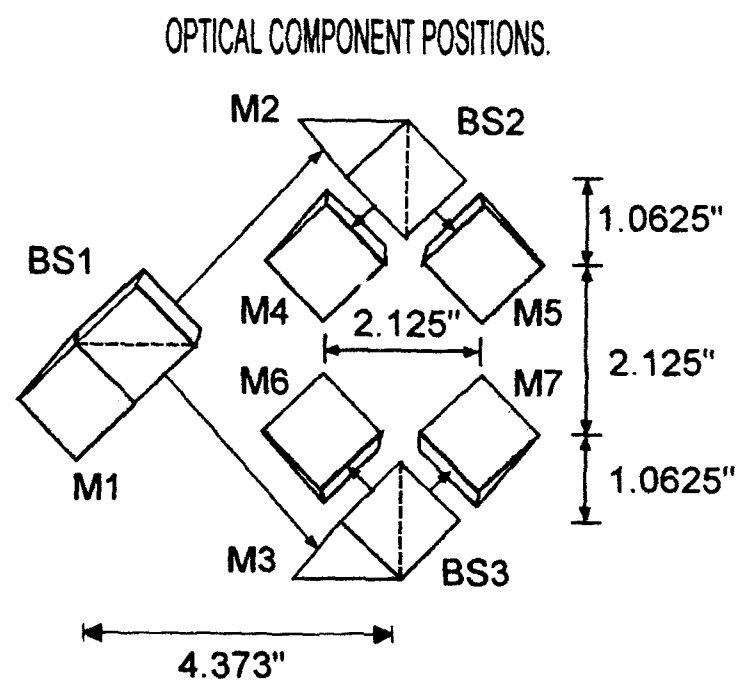


Figure 1. Scale drawing of the optical components of the beamsplitter assembly. The seven right angle prisms used as mirrors are labeled M1 through M7. The three equal intensity beamsplitters are labeled BS1 through BS3.

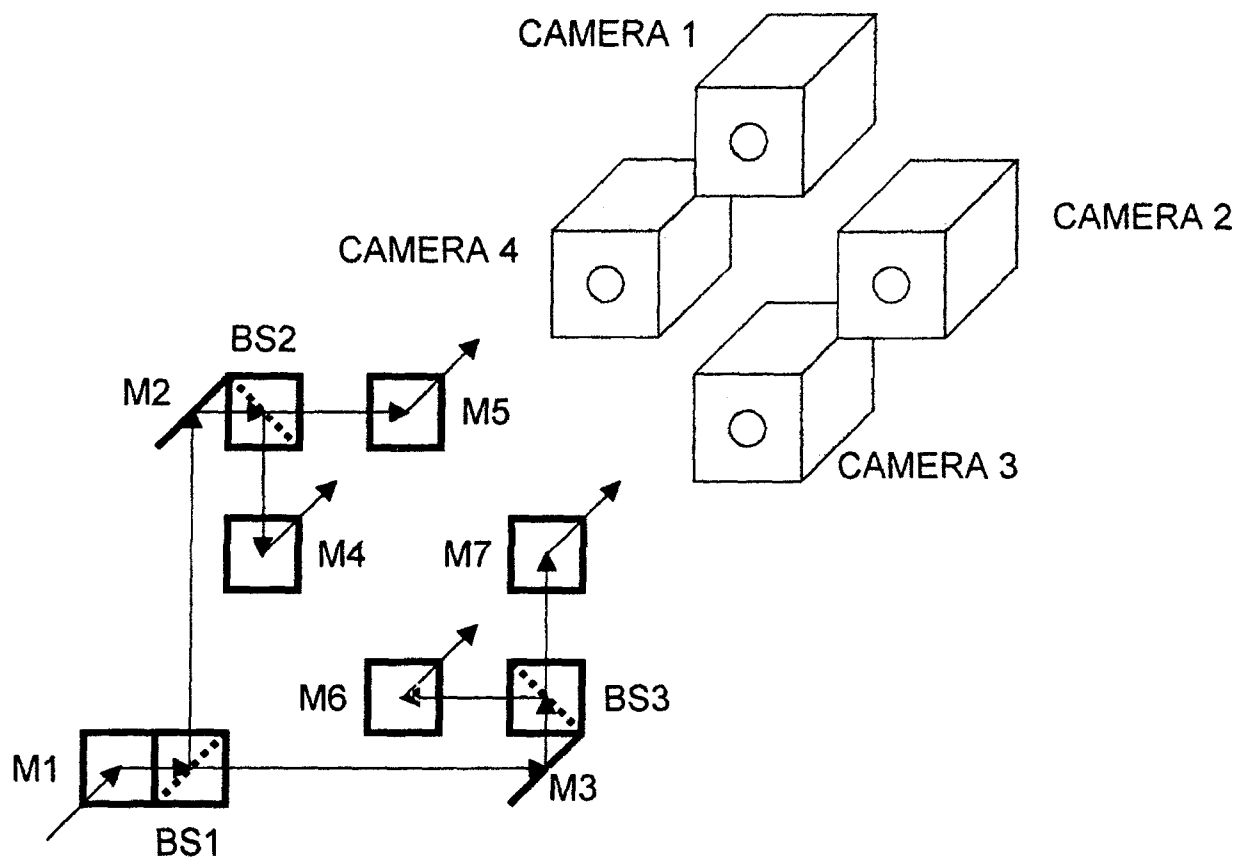


Figure 2. Schematic drawing of the splitter assembly showing the optical path through to each of the gated cameras.



Figure 3. Photograph of the assembled system. The yellow tinted region houses focusing optics. The red tinted region contains the 4-way beamsplitter assembly. The green tinted region highlights the four GOI television cameras.

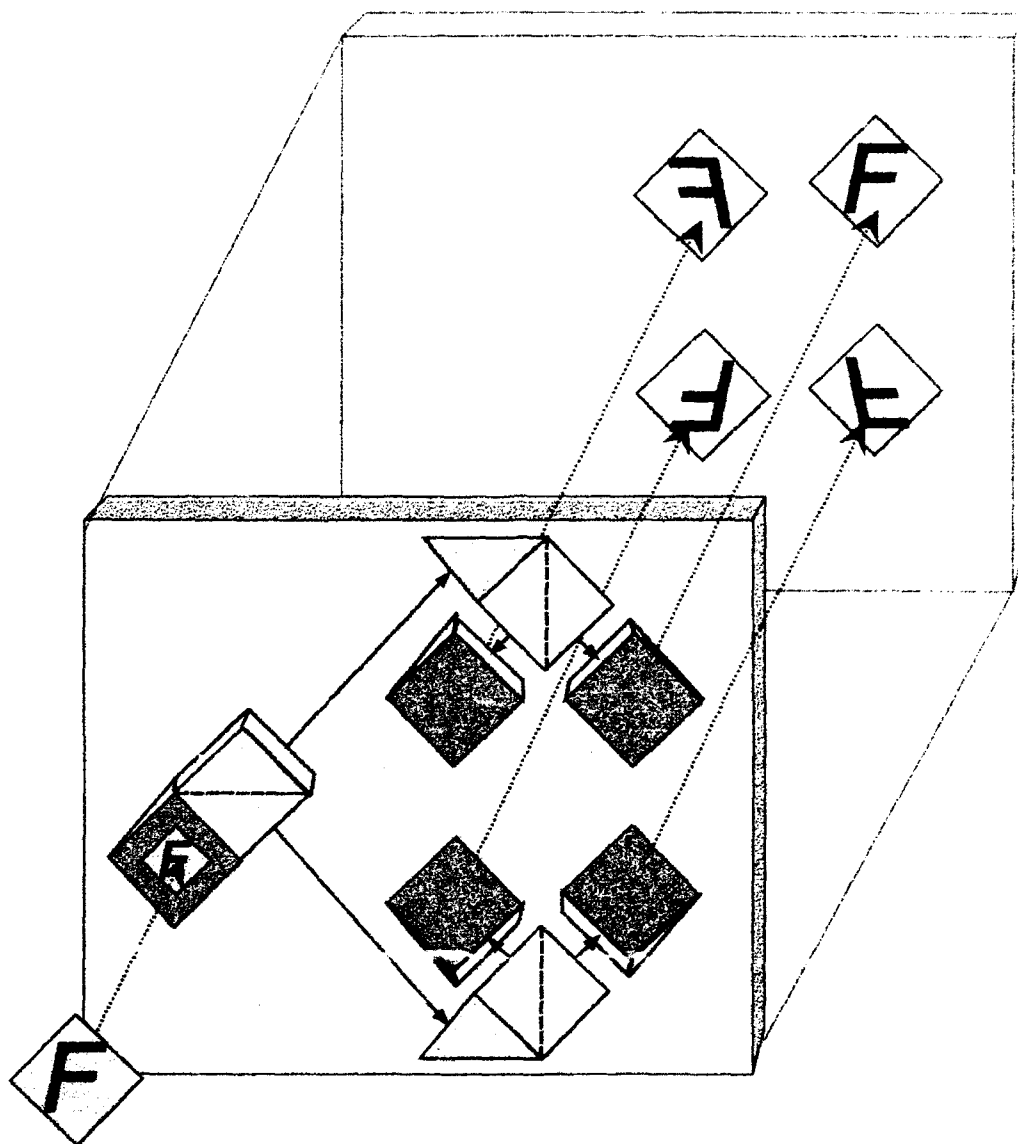


Figure 4. Schematic diagram showing the orientation of the images that emerge from each of the four arms of the beamsplitter assembly. Computer software is used to reorient three of the captured images to bring them to the proper orientation.

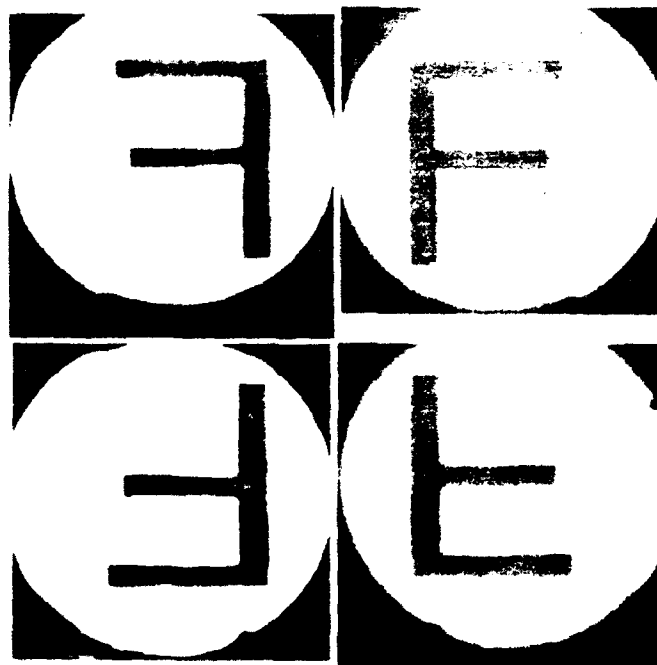


Figure 5. Four images of the letter "F" captured simultaneously by the four gated television cameras through the 4-way splitter assembly. Three of the images are flipped in the horizontal and/or vertical plane by the splitter assembly. The orientation of these images is corrected later by software.